The Freshwater Annelida (Polychaeta, Naidid and Tubificid Oligochaeta, and Hirudinea) of the Great Lakes Region--an Overview

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Abstract
The segmented worms are important components of benthic communities in nearly every freshwater biotope. They are widely distributed, and some groups are found in great abundance. Several of the annelid groups have been used for monitoring and detecting changes in water quality and physical habitats. The habitat and water quality requirements as well as the pollution tolerance of many species of freshwater annelids have been documented in the literature by a few investigators. Practical taxonomic keys are now available to species, but many benthic water quality assessment studies still do not treat the annelid groups adequately because the investigators lack the knowledge and experience in using these keys. Furthermore, most bioassessment monitoring studies do not use adequate sampling and processing (preservation) techniques for aquatic annelids. The inadequate treatment by some investigators represents a loss of valuable ecological information for use in biological assessment of the quality of water resources, water pollution, or other changes in aquatic ecosystems resulting from natural causes or anthropogenic activities. The current aspects of morphology, taxonomy, distribution, and organic pollution to polychaetes, naidid and tubificid oligochaetes, and leeches of the Great Lakes Region species are presented and discussed.

Key Words: macroinvertebrates, polychaetes, oligochaetes, leeches, pollution, water quality, organic enrichment.

Introduction

Benthic animals, including the segmented worms, are commonly used to demonstrate the effects of pollution on the biological integrity of surface waters and changes in the biotic community (species composition, presence or absence, and relative abundance of tolerant and intolerant species) resulting from natural causes and destructive activities by man (Aston 1984; Brinkhurst 1974a,b; Carr and Hiltunen 1965; Goodnight and Whitley 1960; Hiltunen 1967, 1969a-c, 1971; Hiltunen and Manny 1982; Howmiller and Scott 1977; Milbrink 1983; Sawyer 1974; Klemm 1991 and papers cited therein). This paper is a taxonomic overview of the freshwater polychaetes, naidid and tubificid oligochaetes, and leeches of the Great Lakes region with emphasis on their use to demonstrate pollution effects and changes in biotic community. A checklist of the species is found in Table 1.

Annelida is an important and major phylum in the animal kingdom. The body of annelids is divided into rings (somites) or segments with serially arranged organs. The phylum includes three major classes, Polychaeta, Oligochaeta, and Hirudinea. The distribution of aquatic annelids is usually determined by the physical, chemical, and biological characteristics of the environment. Published accounts are relatively sketchy for understanding the roles that some of these characteristics play in the distribution of annelids (gross chemical pollution not

Table 1. Checklist of Polychaetes, Naidid and Tubificid Oligochaetes, and Leeches in the Great Lakes Region.

Class Polychaeta: Order Sabellida

Family Sabellidae
Manayunkia speciosa

Class Oligochaeta: Order Tubificida

Family Naididae
Allonais pectinata

Amphicaeta america

Amphicaeta leydigii

Arcteonais lomondi

Bratislavia unidentata

Chaetogaster diaphanus
Chaetogaster diastrophus
Chaetogaster limnaei
Chaetogaster setosus

Dero digitata
Dero furcata
Dero nivea
Dero obtusa
Dero vaga

Haemonais waldvogeli

Nais alpina
Nais bretscheri
Nais barbata
Nais behningi
Nais communis
Nais elinguis
Nais pardalis
Nais pseudobtusa
Nais simplex
Nais variabilis

Ophidonais serpentina
Paranais frici

Piguetiella michiganensis
Piguetiella blanci

Pristina aequiseta
Pristina breviseta
Pristina leidyi
Pristina longiseta bidentata
Pristina longiseta longiseta
Pristina plumaseta
Pristina synclites

Pristinella acuminata
Pristinella jenkinae
Pristinella osborni

Ripistes parasita

Slavina appendiculata

Specaria josinae

Stephensoniana trivandrana

Uncinais uncinata

Vejdovskyella comata
Vejdovskyella intermedia

Table 1. Checklist of Polychaetes, Naidid and Tubificid Oligochaetes, and Leeches in the Great Lakes Region (continued).

Class Oligochaeta: Order Tubificida

Family Tubificidae

Aulodrilus americanus
Aulodrilus limnobius
Aulodrilus pigueti
Aulodrilus pluriseta

Bothrioneurum vejdovskyanum

Branchiura sowerbyi

Haber cf. speciosus

Ilyodrilus templetoni

Isochaetides freyi
Isochaetides curvisetosus

Limnodrilus cervix
Limnodrilus cervix (variant form)
Limnodrilus claparedianus
Limnodrilus hoffmeisteri
Limnodrilus hoffmeisteri (spiralis form)
Limnodrilus hoffmeisteri (variant form)
Limnodrilus maumeensis
Limnodrilus profundicola
Limnodrilus udekemianus

Phallodrilus hallae

Potamothrix bavaricus
Potamothrix bedoti
Potamothrix hammoniensis
Potamothrix moldaviensis
Potamothrix vejdovskyi

Psammoryctides californianus

Quistadrilus multisetosus

Rhyacodrilus coccineus
Rhyacodrilus montana
Rhyacodrilus punctatus
Rhyacodrilus sodalis

Spirosperma ferox
Spirosperma nikolskyi

Tasserkidrilus harmani
Tasserkidrilus kessleri
Tasserkidrilus superiorensis

Teneridrilus flexus

Tubifex ignotus
Tubifex tubifex

Varichaetadrilus augustipenis

Class Hirudinea: Order Arhynchobdellida

Family Haemopidae

Haemopis grandis
Haemopis lateromaculata
Haemopis marmorata
Haemopis plumbea
Haemopis terrestris

Family Hirudinidae

Macrobdella decora
Philobdella gracilis

Table 1. Checklist of Polychaetes, Naidid and Tubificid Oligochaetes, and Leeches in the Great Lakes Region (continued).

Family Erpobdellidae	
Erpobdella dubia	*Mooreobdella bucera*
Erpobdella parva	*Mooreobdella fervida*
Erpobdella punctata	*Mooreobdella microstoma*
Nephelopsis obscura	
Class Hirudinea: Order Rhynchobdellida	
Family Glossiphoniidae	
Actinobdella annectens	*Helobdella fusca*
Actinobdella inequiannulata	*Helobdella papillata*
Actinobdella pediculata	*Helobdella stagnalis*
	Helobdella transversa
Alboglossiphonia heteroclita	*Helobdella triserialis*
Desserobdella michiganensis	*Marvinmeyeria lucida*
Desserobdella phalera	
Desserobdella picta	*Placobdella hollensis*
	Placobdella montifera
Gloiobdella elongata	*Placobdella ornata*
	Placobdella papillifera
Glossiphonia complanata	*Placobdella parasitica*
	Theromyzon biannulatum
	Theromyzon rude
Family Piscicolidae	
Cystobranchus meyeri	*Piscicola geometra*
Cystobranchus verrilli	*Piscicola milneri*
	Piscicola punctata
Myzobdella lugubris	
	Piscicolaria reducta

withstanding). Despite the fact that annelids may occur in all aquatic habitats and in great numbers, especially certain oligochaete groups, it must be stressed that much work remains to be done on the ecology and pollution biology of the annelids. The improper or inadequate treatment of the segmented worms is attributable, in part, to investigators that lack appropriate experience or do not understand the morphological terms and characters used in practical keys. To interpret the quality of water resources, the water quality requirements and pollution tolerances, the animals should be identified to the species level (Resh and Unzicker 1975).

Class Polychaeta: Order Sabellida: Family Sabellidae

General Morphology and Taxonomy

Polychaetes are segmented annelids typically with parapodia associated with each body segment. A high degree of modification in the basic plan of many polychaetes has resulted in different modes of existence, ranging from sedentary (tubicolous) forms to highly free-moving (errant) forms. The group is very diverse, most forms are mainly found free living; some are commensal with other invertebrates, and only a few are parasitic. The class contains about 85 families and many species, most of which are marine forms. World-wide, only 10 families are represented in freshwater.

In North America only four families and 11 species are represented (Klemm 1985a,c): Nereididae with six species, Ampharetidae with one species, Sabellidae with one species, and Serpulidae with two species. In the Great Lakes Region only the family, Sabellidae is represented by one species, Manayunkia speciosa; it is sedentary and inhabits a tube built of mud or sand and mucus. The size of this species is usully 2 to 5 mm long. The body is divided into distinct regions, the thorax and abdomen, with reduced or vestigal parapodia, with simple capillary chaetae and hooks or uncini. The prostomium is small or indistinct, without appendages. In Sabellidae, the anterior end is modified to form a branchial (tentacular) plume or crown surrounding the mouth which is used for food getting (filter feeding) and respiration. For more information on the taxonomy of the North America freshwater forms, see Klemm (1985a,c).

General Distribution and Ecology

This species is widely distributed in the Neartic region, from Duluth Harbor in western lake Superior to St. Marys River, Lake St. Clair, the Ottawa River in Ontario to Western Lake Erie, Lake Ontario, and the upper St. Lawrence River; eastward to the Finger Lakes and Hudson River, New York, Schuylkill River and Delaware River, Pennsylvania, Egg Harbor River, New Jersey, and Lake Champlain, Vermont, south to North Carolina, South Carolina, and Georgia. It has also been reported from the Pacific northwest, California, and Oregon to Alaska. One reason for not detecting this species more often is its small size; the sieve used to process the sample may have mesh openings too large to retain the specimens. Most specimens may pass through a Standard No. 30 sieve, and a Standard No. 60 should be used.

Mackie and Qadri (1971) reported, during a limnological survey of the Ottawa River, that specimens of M. speciosa occurred only in substrates composed of silt and sand and in moderately moving waters. Hiltunen (1965) also found a large number of M. speciosa at the mouth of the Detroit River, suggesting some relationship between water movement and the frequency of occurrence. Specimens in the Mackie and Qadri study did not occur in polluted water where BOD value exceeded 4 ppm nor where the DO content was less than 5 ppm. M. speciosa has also been found in lentic habitats, many locations in Lake Erie (Hiltunen 1965, Krieger 1990), and in several lakes in Alaska (Holmquist 1973). Spencer (1976) found it in Cayuga Lake, New York at depths of 20 m or less where densities of more than 1000/sq. m were found occasionally. Poe and Stefan (1974) reported this polychaete from the Schuylkill River, Pennsylvania, near the type-locality, and they reported that it appears to have a wide range of tolerances for environmental parameters such as DO (1.8 to 14.0 ppm), depth (0.3 to 16.0 m), pH (6.8 to 8.8), and water temperature (2.8 to 28.3°C) (obviously as low as 0°C because it survives ice-cover seasons), and concluded that the only environmental factor which may limit its distribution is the requirement for fine particulate material in the substrate for the construction of the tube in which it lives (gross chemical pollution notwithstanding).

Class Oligochaeta

Introduction

Naidids and tubificids are predominantly found in freshwater but some are strictly marine forms. Most oligochaetes have chaetae, with a few exceptions, and have no parapodia as in the polychaetes. The body is segmented into somites or compartments separated by septum, and each segment by convention is indicated by a Roman numeral, progressing from anterior to posterior. Segment I (including mouth and prostomium) is devoid of chaetae, hence numerical orientation of segments is achieved by counting posteriad of the chaetophorous segments, beginning with II. Normally each segment bears four fascicles "bundles" of chaetae, two dorso-lateral and two ventro-lateral. There are two basic types of chaetae (crotchets and capilliforms) whose numbers and morphology in the various body regions are taxonomically important. A crotchet can be straight or curved (sigmoid), and usually possess a more or less median thickening (the node or nodulus), and may be simple-pointed or have a bifid (cleft) distal end. Crochets are found in all oligochaetes. Capilliform chaetae which are elongate and simple-pointed, may be smooth or finely serrated. Capilliform chaetae when present, are found only in the dorsum of the Naididae and Tubificidae. For more detailed information on aquatic oligochaete biology, see Brinkhurst and Jamieson (1971), Brinkhurst and Cook (1980), Bonomi and Erseus (1984), and Brinkhurst and Diaz (1987).

Order Tubificida: Family Naididae

General Morphology and Taxonomy

Naidids are relatively small, commonly I mm to I0 mm and more or less transparent when alive. All or nearly all can be identified to species by the external morphology, particularly the shape and arrangement of the chaetae. There are 20 genera and more or less 48 species known or likely to occur in the Great Lakes region. In North America 2I genera and 75 species are reported. Keys work well for most species, but some species descriptions are incomplete for North American material. The kinds of chaetae are much like those in the Tubificidae, except the naidids have dorsal acicular (short needle-like) chaetae that accompany the long capilliform (hair) chaetae. Some species of naidids also bear pectinate chaetae like the tubificids. Dorsal chaetae can begin in segment II or posteriad to it; dorsal chaetae that accompany capilliform (hair) chaetae are often very different from ventral chaetae. Dorsal fascicles often contain 1-2 capilliform chaetae and I-2 acicular chaetae. In summary, some naidids have ventral chaetae only (Chaetogaster spp.); other species have dorsals and ventrals with bifids only, while still other species have ventrals bifid and dorsals with capilliform plus simple, bifid, pectinate, or palmate acicular chaetae. The dorsal chaetae may begin in II, III, or further back, usually V or VI, rarely beyond. Some species may have eyes; may be found budding (a form of asexual reproduction), and when sexually mature, may bear genital chaetae in segments V or VI; spermathecae in segments IV, V, or VII; male pores on segments V, VI, or VIII. However, these features are not used in species identification. For more information on taxonomy of the naidids, see Hiltunen and Klemm (1980, 1985), Brinkhurst (1986), and Brinkhurst and Kathman (1983).

General Distribution and Ecology

The naidids are an ecologically diverse group (Leaner 1979) and are found in both lotic and lentic waters. The naidids are widely distributed and commonly inhabit the littoral zones of lakes or other shallow waters in streams, ditches, and ponds. Some species are sediment dwellers (like tubificids) while other species are characteristically found among the aquatic plants. Naidid populations are usually reduced where siltation and mud occur. Plants with a thick growth habit and well-developed periphyton community can support sizeable naidid populations. Riffles and similar areas where the substrate is primarily sand and gravel often contain substantial naidid populations. Longitudinal zonation of naidids along rivers has been demonstrated. Learner et al. (1978) concluded that factors associated with changes in altitude and slope of a river (water velocity, substrate type, presence and type of vegetation, and the influence of municipal and industrial wastes) can be important in influencing the distribution of naidids. They are generally less significant in lakes where they are confined primarily to the littoral zone. The behavior of most naidids is unlike that of most other oligochaetes because some naidids can swim as well as crawl, and others are small enough to be passively carried by strong water movements.

Feeding habits of most species are unknown, but some have been observed to feed on detritus, grazing upon bacteria, protozoans, and algae. Probably most oligochaetes are herbivorous, but some Chaetogaster species are primarily or perhaps entirely predaceous. Reproduction occurs by paratomy (architomy, asexually budding), where the posterior segments of the naidid develop into daughter zooids that break free after development is complete, or by fragmentation. Sometimes the worms are found consisting of two or more individuals that have not yet separated from the parent (anterior) section. Sexual reproduction is considered uncommon in many species.

Order Tubificida: Family Tubificidae

General Morphology and Taxonomy

Tubificids are medium-sized to large worms, commonly more than 20 mm long, that never have eyes, never reproduce by asexual budding, but occasionally regeneration of the posterior section in some species suggests fragmentation. A variety of chaetae are found among the species. Crotchets are always present but capilliform (hair) chaetae may or may not be present depending on the species. Most species are red when alive and coil or loop when disturbed. In the Great Lakes region there are presently 17 genera and 37 species. There are 21 genera and 64 species reported to occur in North America. Tubificids are identified by the characteristic shape of the somatic chaetae and their genital chaetae (spermathecal or penial chaetae) if present, or by mature male genitalia. In some species penis sheaths in segment XI are especially helpful in species identification. Spermathecae are located in segment X, and males pores are in Segment XI. Dorsal chaetae always begin on segment II, dorsal chaetae are often broadly similar in form to ventral chaetae; dorsal fascicles often bear a complement of more than 2 capilliform (hair) chaetae and 2 or more crotchets. Therefore, some species of tubificids have dorsal and ventral chaetae bifid; other species have dorsal capilliform and pectinate chaetae and ventrals mostly bifid. Pectinate chaetae may be narrow and hairlike distally in appearance. Some species have dorsal capilliform and bifid chaetae and ventral bifid chaetae. For more information on the taxonomy of the tubificids, see Stimpson, Klemm, and Hiltunen (1982, 1985) and Brinkhurst (1986, 1989).

General Distribution and Ecology

Tubificids are most commonly found in soft sediments rich in organic matter; several tubificid species characteristically live in large numbers in habitats that receive organic pollution (Aston 1984, Brinkhurst 1974a,b, Carr and Hiltunen 1965, Goodnight and Whitley 1960. Hiltunen 1967, 1969a-c, 1971, Hiltunen and Manny 1982, Howmiller and Scott 1977, Krieger 1990, Milbrink 1983). Tubificids respire cutaneously, but some species can tolerate anoxic conditions and environmental stresses (e.g., Limnodrilus hoffmeisteri and Tubifex tubifex). A number of species in the family are very stress-sensitive (Hiltunen 1967, Howmiller and Scott 1977, Milbrink 1983). Tubificids burrow in soft sediments, often in tubes of mud and mucus secretions, as the classic name implies. A few species occur in fine gravel or sand. The quantity and quality of organic matter reaching the sediment may be more important in determining which tubificid species will occur in a locality (gross chemical pollution notwithstanding) than the physical-chemical variables of water or sediment (Brinkhurst and Cook 1974).

Tubificids are mostly deposit feeders living on organic detritus and its associated bacteria, microflora, and fauna. Tubificids typically feed with their heads buried below the sediment surface with their tails protruding above it. The feeding activities of tubificids play an important role in mixing the physical and chemical characteristics of sediments (Brinkhurst 1974). Most tubificids reproduce by sexual reproduction even though they are hermaphrodites. Tubificids enclose their eggs in cocoons and deposit them on sediments.

Class Hirudinea (Not Hirudinoidea)

Leeches are serially segmented worms and are considered closely related to the oligochaetes. They are also hermaphroditic, i.e., they contain both male and female organs in each individual. Muscles and a hydrostatic skeleton are used in locomotion. The nervous, excretory and vascular systems are segmentally arranged. Leeches have well-developed anterior and posterior sucker, 34 segments (indicated by Roman numerals I-XXXIV)) which are subdivided into annuli, a reduced coelom and intestinal caeca, and usually two separate male and female gonopores with male gonopore anterior to the female gonopore. Leeches are devoid of chaetae, except Acanthobdella peledina, a leech which has chaetae in the anterior segments of the cephalic region (Klemm 1985b,c). Although some leeches are well adapted to a sanguivorous existence, the group is also well-represented by species which are both predatory and can engulf small animals whole or parasitic fluid-feeders. Leeches are found on all the continents, in terrestrial, freshwater, estuarine, and marine environments.

General Taxonomy and Morphology

Five families in the orders Arhynchobdellida and Rhynchobdellida are represented in the Great Lakes region: Haemopidae, Hirudinidae, Erpobdellidae, Glossiphoniidae, and Piscicolidae. Nineteen genera and 43 species have been recorded from that region. Twenty-one genera and 66 nominal species presently are reported to occur in North America. For more information on the taxonomy of leeches, see Klemm (1985b,c, 1991) and Sawyer (1972, 1986).

Leeches are found in most freshwater habitats, but are often ignored by biologists because they are thought to be difficult to identify to genus and species. Also, investigators neglect them because they lack an understanding of the diagnostic (morphological) terms and characters used in keys to identify specimens to the lowest taxonomic level.

The external morphological characters are usually sufficient for the identification of most leeches. Internal characters used to identify certain species of Haemopis are discussed in Klemm (1985b,c). The general external diagnostic features that are important for identifying the leeches to species are: size of mouth, general shape of body, form of suckers, form of cephalic region, number and arrangement of eyes, jaws and teeth, eyespots (ocelli), papillae, pulsatile vesicles, digitate processes on rim of caudal sucker, caudal-sucker separation from body on narrow pedicle, copulatory gland pores, the number of annuli between gonopores, and pigmentation patterns. Typically, the mouth opening of the haemopids and hirudinids is medium to large, occupying the entire sucker cavity, and the body is large, linear, elongate and well-muscled, length 75-300 mm. They are good swimmers. Haemopids and hirudinids always have 5 pairs of eyes. The mouth opening of erpobdellids is medium, occupying the entire sucker cavity; the body of erpobdellids is moderate size, linear, elongate, length to 100 mm, and they are also good swimmers. They usually have 3, or 4 pairs of eyes (or eyes absent). The mouth of glossiphoniids is a small pore on the rim or within the oral sucker cavity; the body of this group is dorso-ventrally flattened with the posterior half usually much wider than the tapering cephalic end, length to 40 mm. They have l, 2, 3, or 4 pairs of eyes. The mouth of piscicolids is a small pore within the oral sucker cavity, and the body of the piscicolids is cylindrical, narrow, posterior half can be slightly flattened, length to 30 mm. The body may be divided into a narrow neck (trachelosome) and wider body (urosome) regions; caudal sucker with or without eyespots, and body with or without pulsatile vesicles. Piscicolids can have one or two pairs of eyes (or eyes absent).

General Distribution and Ecology
In North America, freshwater leeches reach their greatest species diversity in lakes, permanent and temporary ponds, woodland pools, bogs, wetlands, rivers, and streams (Klemm 1972, Sawyer 1972). Klemm (1977, 1991) summarized the distribution of leeches in the Great Lakes states (Illinois, Indiana, Michigan, Minnesota, New York, Ohio, and Wisconsin) bordering the Great Lakes, including Ontario, Canada. Additional collecting in all habitats, substrate types, and host organisms will undoubtedly extend the regional distribution of some taxa.

The leeches of the Great Lakes region are a significant part of the continental freshwater fauna. Leeches are biologically important in food webs, and at trophic levels they function mainly as ectoparasites, predators, or both. An important ecological factor in the distribution of leeches is the availability of prey. Other environmental factors, such as composition of substratum, lentic or lotic waters, depth, size and type of water body, hardness and pH, dissolved solids, water temperature, dissolved oxygen, siltation and turbidity, and salinity are characteristics of aquatic habitats that also influence leech distribution and abundance (Klemm 1972, 1991; Sawyer 1974), not withstanding toxic substances in the aquatic environment. We have a relatively sketchy understanding of the role that these and other environmental factors play in the distribution of leeches. It must be stressed that much work remains to be done before we can have a clear picture of the problem.

The little we know of the feeding habits of leeches indicates that they are far more diverse than most people realize; many are not sanguivorous (blood feeders). The Haemopidae have no teeth or have varied and poorly developed jaws that are armed with small numbers of blunt teeth for masticating food, and are able to swallow prey whole. They are mainly predators of macroinvertebrates, but the ones with teeth are perhaps capable of sucking blood. In the Hirudinidae, the jaws are well developed, armed with numerous small, sharp, saw-like teeth suitable for making cuts in the epidermis of prey, such as reptiles, amphibians, and mammals. These leeches are blood sucking ectoparasites. Surprisingly, studies on the North American haemopids and hirudinids indicate that these leeches are predominantly predatory and extremely opportunistic, and consume larvae and eggs of amphibians and small invertebrates. They dwell mostly in freshwater, but some species can travel overland, and a few species are terrestrial. In Erpobdellidae, the mouth is large and adapted to predation. It contains a muscular pharynx for crushing and swallowing macroinvertebrate prey whole. They are highly mobile and are good swimmers. They live exclusively in freshwater. The Glossiphoniidae are without teeth or jaws and have a very small oral opening (pore). This name refers to the mechanism by which these leeches feed. They insert a tube-like proboscis into their prey and suck out the body fluids. The glossiphoniids parasitize turtles, mollusks, waterfowl, fishes, amphibians, mammals, including man, and even other leeches. They are ectoparasites or predators. Most travel slowly with a looping movement, but a few species are active swimmers. Brooding behavior is well developed, and cocoons are brooded over substrate or directly on the venter of the parent. They are found exclusively in freshwater. The Piscicolidae are primarily ectoparasites on fish. Some are permanent parasites on specific hosts, but most are opportunistic and feed on a variety of host fishes. A few feed on invertebrate groups, such a Decapoda and Cephalopoda. Piscicolids generally have a large and well-developed anterior sucker surrounding the mouth. As in the glossiphoniids, the oral opening is small. To feed, piscicolids insert a protruding sucking proboscis into their host. Parent leeches lay hard-shelled cocoons on a substrate, but they do not brood their cocoons or young. Only a few piscicolids are active swimmers. Muscles are generally poorly developed and locomotion is usually by looping movements over a substrate or host. Most species are marine, but some are found in brackish or fresh waters.

Tolerance to Organic Pollution

The species of annelids in the Great Lakes region that are commonly or occasionally associated with organically enriched waters are indicated in Table 2A-C. The tolerance values in Table 2A-C can be used with the Trophic Condition Index (Howmiller and Scott 1977; Milbrink 1983) and modified Hilsenhoff Biotic Index (Klemm et al. 1990; Plafkin et al. 1989). However, more pollutional studies are needed for these annelid groups because little is known about their tolerances and the biological effects of various contaminants. For more information on the water quality requirements and pollution tolerance of freshwater naidids, tubificids, and leeches, see Brinkhurst (1974a,b), Carr and Hiltunen (1965), Hiltunen (1967, 1969a-c), Howmiller and Scott (1977), Klemm (1972, 1991), Klemm et al. (1990), Krieger (1990), Milbrink (1983), and Sawyer (1974).

General Collection and Preservation

Aquatic worms are usually collected using dredges, grabs, cores and other sampling devices that provide bulk collections of bottom subtrate. This material is then sieved or hand-picked so that the organisms are separated from the accompanying silt and debris. This must be done carefully, especially if a sieve is used. The abrasion of the soft-bodied worms against a sieve surface may break specimens or damage the specimens by breaking or displacing chaetae, particularly capilliform (hair) chaetae, for example. Although a US Standard No, 30 mesh sieve (28 meshes per inch, 0.595 mm openings) is usually used, it should be noted that many small individuals may be lost during the sieving process and that the use of a finer sieve (for example, No. 60 mesh, 0.25 mm opening) or no sieving at all may be required to ensure collection of all individuals. Even when sieving has been accomplished carefully, some individuals will nevertheless fragment. Only head-end sections and whole worms should be enumerated. The initial sorting of specimens from sediment residue in the laboratory should be done at a 5-10 X magnification using a dissection microscope or

Table 2A. Pollution Tolerance of Selected Freshwater Annelids

Taxa	Tolerance to Organic Wastes* T	F	I
ANNELIDA - POLYCHAETA			
SABELLIDAE			
Manayunkia speciosa		3	
ANNELIDA - OLIGOCHAETA			
NAIDIDAE			
Amphichaeta americana		2	
Chaetogaster diaphanus		2	
C. diastrophus		2	
Dero digitata		2	
D. nivea		3	
D. obtusa		3	
D. pectinata		2	
Nais barbata	4		
N. behningi		3	
N. bretscheri		3	
N. communis	4		
N. elinguis	5		
N. pardalis	4		
N. simplex		3	
N. variabilis	5		
Ophidonais serpentina	4		
Pristina aequiseta		3	
Slavina appendiculata		2	
Specaria josinae		2	
Stylaria fossularis		3	
S. lacustris		3	
Vejdovskyella comata			1
V. intermedia	4		

*Ranking from 0 to 5 with 0 being the least tolerant. T = tolerant; F = facultative; I = intolerant

Table 2B. Pollution Tolerance of Selected Freshwater Annelids.

Taxa	Tolerance to Organic Wastes* T	F	I
ANNELIDA - OLIGOCHAETA			
TUBIFICIDAE			
Aulodrilus americanus		3	
A. limnobius		3	
A. pigueti		3	
A. pluriseta		3	
Bothrioneurum vejdovskyanum		2	
Branchiura sowerbyi	4		
Ilyodrilus templetoni		3	
Isochaetides curvisetosus		2	
Limnodrilus cervix	4		
L. claparedianus	4		
L. hoffmeisteri	5		
L. maumeensis	5		
L. udekemianus	5		
Potamothrix moldaviensis		3	
P. vejdovskyi		3	
Quistadrilus multisetosus	4		
Spirosperma carolinensis		3	
S. ferox		3	
S. nikolskyi		2	
Tubifex tubifex	5		

*Ranking from 0 to 5 with 0 being the least tolerant. T = tolerant; F = facultative; I = Intolerant.

Table 2C. Pollution Tolerance of Selected Freshwater Annelids

Taxa	Tolerance to Organic Wastes* T	F	I
ANNELIDA - HIRUDINEA			
ERPOBDELLIDAE			
Erpobdella parva	4		
E. punctata	4		
Mooreobdella microstoma	4		
HAEMOPIDAE			
Haemopis grandis		3	
H. marmorata		3	
GLOSSIPHONIIDAE			
Alboglossiphonia heteroclita		3	
Gloiobdella elongata	4		
Helobdella stagnalis	4		
H. triserialis		3	
Glossiphonia complanata	4		
Placobdella multilineata		2	
P. ornata		3	
P. papillifera		3	
P. parasitica		3	
PISCICOLIDAE			
Myzobdella lugubris		3	
Piscicola punctata		3	

*Ranking from 0 to 5 with 0 being the least tolerant. T = tolerant; F = facultative.

lens. They can also be selectively hand-picked, fixed, and preserved in the field.

Leeches are also found attached to various substrates such as rocks, boards, logs, or almost any inanimate object littering both lentic and lotic environments or collected from prey organisms. Annelid specimens should be fixed in 5010% formalin, and transferred after 48 hours to 70% ethanol or 5-10% buffered formalin for storage. Undesirable shrinkage is kept to a minimum with this process. The use of alcohol as a fixative should be avoided because polychaetes, oligochaetes, and leeches initially preserved in alcohol without first being fixed in formalin tend to deteriorate and disintegrate. If the specimens of oligochaetes are to be cleared and they have been preserved in 70% alcohol, they should be placed in 30% alcohol and then in water for a short time to leach out the alcohol to enable placement into a tissue-clearing solution (e.g., Amman's lactophenol). Alcohol retards the clearing process of Amman's lactophenol.

To allow internal structures to be seen, oligochaete specimens should be cleared before specific examination. Temporary mounting media, Amman's lactophenol (l00g phenol, l00 mL lactic acid, 200 mL glycerine, and l00 mL water) or CMCP-9, or CMCP-10, can be used for rapid processing of specimens. Oligochaete specimens must be cleared and mounted on glass slides for examination under a compound light microscope capable of magnification up to 1000X (oil immersion). An 18 mm diameter, No. 0 or 1 round cover glass is appropriate because it will adequately accommodate nearly the size range of naidids and tubificids and the shape allows for maneuvering the specimens into the most desired position by gentle pressure and rotation of the coverglass. When preparing a temporary or permanent slide mount, an attempt should be made to place the specimen on its side, revealing both dorsal and ventral fascicles of chaetae. Permanent mounts of oligochaetes can be made following alcohol dehydration of specimens and clearing, using methyl salicylate or xylene, and mounting the specimens in a synthetic resin, such as Harleco's Coverbond or Canada balsam. Permanent mounts of oligochaetes are suitable for systematic study and may last over 20 years. Most leech specimens can be identified to species by examining the external features using a dissecting microscope (450X). Additional instructions for sorting, processing, and identifying polychaetes, naidid and tubificid oligochaetes, and leeches specimens can be found in a number of taxonomic guides (Brinkhurst 1986; Hiltunen and Klemm 1980; Stimpson, Klemm, and Hiltunen 1982; Klemm 1985a-c; Klemm at al. 1990).

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